The Osmotic Pressure of Cane Sugar Solutions at 5°.

DISSERTATION.

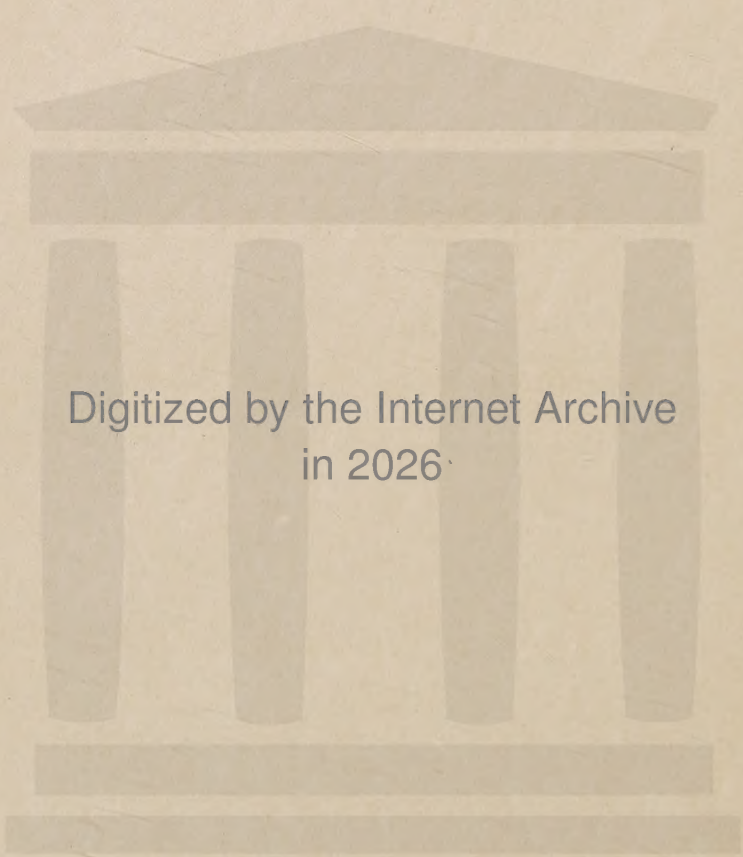
SUBMITTED TO THE BOARD OF UNIVERSITY STUDIES OF THE JOHNS HOPKINS UNIVERSITY FOR THE DEGREE OF DOCTOR OF PHILOSOPHY.

BY

EUGENE EDWARD GILL.

1909

CHICAGO, ILL.
1910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The author wishes to express his sincere gratitude to President Remsen, Professor Morse, Professor Jones, Associate Professor Acree for instruction in the lecture room and laboratory, and to Dr. Schwartz for instruction in his second subordinate subject. Especial thanks are due to Professor Morse, under whose guidance this investigation was pursued. The author is indebted also to Dr. W. W. Holland for assistance in connection with the work.

THE OSMOTIC PRESSURE OF CANE SUGAR SOLUTIONS AT 5°.

In connection with the determination of the temperature co-efficient of the osmotic pressure of cane sugar solutions, which work is being carried out in this laboratory, it seemed advisable to repeat the series of measurements at 5°. In 1907, Dr. P. B. Dunbar made a series of measurements of the osmotic pressure of cane sugar solutions at approximately this temperature.

Since then, however, many improvements have been made in the method, so that the degree of accuracy of the work has been very much increased. Further, it seemed necessary to have a series of measurements at 5°, which had been taken under the same conditions as the series at other temperatures with which it is desired to make comparison; namely, at 0°, 10°, 15°, 20°, 25°, and 30°. The improvements in the method may be discussed briefly under three general heads: First, cells; second, temperature regulation; third, manometers.

In this series all the measurements have been taken with the new style cell, which was designed last year. The construction of this cell is such that the time of setting up and taking down of the cell after a measurement is very materially reduced. With the old style cell, with which the earlier measurements at 5° were taken, much time was consumed in setting up the cell, the cell being held in the warm hand all the time, so that temperature effects were produced and dilution occurring, since the water on the outside of the cell always dilutes the solution on the inside unless the maximum osmotic pressure is developed.

Again, when the cell was taken down, aside from the time consumed in the operation, there was the disadvantage of diminished pressure on the cell contents when the manometer was withdrawn. This caused further dilution. Under these conditions it was impossible to tell whether the change in rotation observed at the end of the experiment was due entirely to these, or in part to other, causes of dilution, or to the inversion of the cane sugar during the progress of the measurement.

With the use of the new style cell and the improved arrangement for closing the cell, which has been described in an article by Morse and Mears in The American Chemical Journal for September, 1908, no change in rotation has been found in any case where the cell has developed its maximum osmotic pressure. All former losses in rotation were then certainly due mainly to dilution of the cell contents during the manipulation of the cell and its manometer prior to and subsequent to the measurement.

The hypodermic needle and its use as described in the article above referred to has been modified somewhat, but not changed in its essential features. The head of the needle has been replaced by a threaded brass cap upon which is placed a stout leather washer. A steel plug, threaded to fit the brass cap on the needle is used to close the opening after the manometer has been forced into the cell the desired amount. The advantage of this method of closing the cell is that it can be closed at atmospheric pressure, and in less than a minute's time. In taking down the cell, it is only necessary to remove this steel plug and atmospheric pressure on the cell contents results at once. The cell can be taken down without subjecting the contents to the least diminished pressure.

In the treatment of the membranes, some observations have been made during the year's work that should be mentioned. It is essential that the membranes be soaked for sometime in thymol water between successive measurements. The necessity of this soaking has been impressed on us by the improved behavior of the membranes after a vacation. Membranes which had been soaking with frequent changes of water during the summer months behaved exceptionally well in the fall. Successive measurements could be taken with them with only a day or two between. As the work went on, however, it became evident that these membranes were requiring more and more rest between measurements. The same observation was made with a new lot of membranes that were developed during the fall months. An occasional measurement was secured from some of these membranes before the Christmas holidays, but they were by no means reliable membranes up to that time. It so happend that they had two weeks' rest with the usual soaking in thymol water, and when we came to take measurements with them in January they turned out to be the most reliable membranes we had. This will be evident, upon an examination of the tables showing the measurements, by the frequent occurrence of cells J and K in the work.

We are not able to come to any conclusion as to why the soaking and resting of the membranes is beneficial. The good condition of the membrane can only be judged by the results it produces, since, from the nature of the case, it can be examined in no other way. It seems unlikely that the good results are due altogether to a removal from the membrane by the water of substances foreign to it. If the benefit should be due to the rest, one has plenty of analogies in the mechanical world. It is well known that to obtain the greatest efficiency from machinery run under a high strain frequent rest is necessary. The membranes which we use are certainly very delicately constructed and are subjected to comparatively large pressures, in the case of normal solutions about twenty-six atmospheres being developed.

Since the first series of measurements were made at 5° many changes have been made in the baths in which the cells are placed while the experiment is in progress, with a view to preventing entirely what are known as "thermometer effects."

The temperature of the water in this bath is regulated by a circulating system which may be briefly described. Supported on an open frame work near the bottom of the bath is a series of connected horizontal brass pipes with an aggregate length of 10 meters. The hydrant water enters this system at the lowest point and passes through a succession of pipes, always in a horizontal or upward direction (to prevent the collection of air), thence through a vertical pipe to the air space above. The vertical pipe here connects with a second system of horizontal pipes, placed one above another, which is fixed to the walls of the air space; and the water, after circulating through this, enters a third system of horizontal pipes which is suspended from the top of the bath. If necessary the hydrant water is cooled, by passing it through a block tin coil surrounded by ice, before it enters the bath. The slowly circulating water, while passing through the pipes lying in the bottom of the bath, is warmed nearly to the temperature of the bath water, and it may not, on that account, be able, while passing through the upper portion of the system, to keep the temperature of the air space low enough; hence provision is made for the reinforcing of the stream with an additional quantity of cold water while it is running through the upper part of the bath.

The water is pumped first over the cool surface—i. e., the pipes near the bottom, and then over a heated surface which consists of two stoves, either of which may be operated independently of the other, though both are under the control of the same thermostat. The stoves consist of a high candle power electric bulb enclosed in a galvanized iron tube which is located in the end of the bath not covered by the superstructure.

These arrangements are satisfactory for the maintenance of constant temperatures in the lower section of the bath—i. e., in the water in which the osmotic cells are placed for a measurement of pressure, but they were found to be insufficient to maintain the same temperatures in the upper section—i. e., in the air space in which the upper ends of the manometers are located. Even the rapid pumping of the air in this section through the pipes lying in the water, and the introduction of a small fan, propelled from the outside, to agitate the air, did not fully neutralize the effect of external conditions. It was therefore decided to bring these external conditions under better control by making the necessary provision for keeping, outside of the bath, approximately the same temperature as was maintained on the inside.

The bath is located in a room, 3.3 meters in length, 2 meters in width, and 2.6 meters in height. This space is now regulated by heating and cooling devices as occasion demands. The cooling device consists of a series of galvanized iron pipes, having a total length of 100 meters, through which the hydrant water circulates. Half of the pipe is suspended from the top of the room in parallel lengths equal to the length of the room. These pipes have a diameter of about 50 mm. and present, therefore, a large cooling surface. The remainder of the pipe is smaller (25 mm. in diameter), and is cut into two-meter lengths, which are compactly arranged in a large ice box. The water enters the ice box directly from the main supply, and, after passing through the series of pipes in the box, ascends through a vertical pipe to the system of symmetrically distributed large ones in the top of the room.

There are two varieties of heating devices in use. One of these consists of two small electric stoves (incandescent lamps in galvanized iron cylinders), which are situated outside the bath, but are controlled by a thermostat in the air space of the bath. The other heating arrangement is a gas stove controlled by a thermostat situated outside the bath, and set for a temperature which is a degree or two below the temperature to be maintained in the bath, so that the final heating of the room may always be accompanied by the electric stoves. The gas stove is, therefore, only used when much heat is needed. Since the electric stoves are regulated by the thermostat in the air space of the bath they can burn only so much as is necessary to bring the temperature of the space up to that of the water in the bath. The air in the room is kept in constant circulation by a motor fan which is located with a view to keeping the temperature of all parts of the room as uniform as possible. This fan is operated by the motor which runs the pumps in the bath.

Another device which can be used at times to bring the temperature of the room to the desired point, when the temperature out of doors is lower and that of the room higher than desired, or, when that out of doors is higher and that of the room lower than desired, consists of a large wooden air shaft running from a window, over the room in which the bath is placed, and making a right angle bend opening through the roof of the bath room near, and back of, the fan above mentioned. Air from the outside is pumped into the room,

when desired, by a motor fan placed in the shaft, taken up by the fan in the room, and kept in circulation.

With these facilities for cooling and heating, a variety of constant temperatures can be kept. Most of the measurements of this series were taken without the use of ice. We were, however, compelled to use ice around the block tin coil with several measurements towards the end of the work. Constant temperature of both water in the bath and the air space above the water was maintained throughout the series, except in two or three instances. and these variations were due to accidental and temporary influences, and not to any defect in the temperature regulation system. The variations from 5° were so small in amount, and maintained for so short a time, that it is not thought that the ratio of osmotic to gas pressure was sensibly affected.

A further improvement in temperature regulation as applied to the measurement of osmotic pressure consists of a small bath constructed much on the same lines as the large bath in which the measurement of osmotic pressure proceeds. This small bath is placed in the main laboratory room where the work of setting up the cell is done. It is kept at the same temperature as the large bath in which the measurements are made. The use of this bath is to bring the solution whose pressure is to be measured, and the liquids in which the cells are immersed during the measurement to the temperature at which the osmotic pressure is to be measured. This bath is also used to maintain the filled and closed cells at the right temperature, while they are under observation, before going into the large bath. A full description of these baths was given by Morse and Holland in The American Chemical Journal for February, 1909.

It is probable that a large part of the variation in osmotic pressure, which is still found in some duplicate measurements, is due to inaccuracies in the manometers. During the present year much time has been spent in calibrating and re-checking the nitrogen volumes of the manometers in use. The general method employed in this part of the work has been described by Morse and Lovelace in the American Chemical Journal for October, 1908. All the manometers used in this series of measurements had their nitrogen volumes redetermined just prior to the commencement of the work. A new cathetometer has recently been installed and a small house especially built for the apparatus used in the calibration of manometers and in the comparison of them with the standard manometer. The temperature inside this house is regulated by an electric stove and fan to keep the air in circulation, so that the work of comparison of manometers and the determination of their nitrogen volumes may proceed at a constant temperature, and, therefore, more rapidly as well as more accurately.

That the improvements outlined above have resulted in increased accuracy in the work is evident from a comparison of the osmotic pressures now obtained with those obtained in earlier series. It will be noticed that the actual osmotic pressures now measured are somewhat greater than those obtained in former series. Eight series of measurements at temperatures from 0° to 25° have been carried out before this one. In the earlier ones the evidence bearing upon the temperature coefficient of osmotic pressure was of a very unsatisfactory kind. In the later work, in which a greater degree of accuracy had been secured, the evidence of the existence of a temperature coefficient became clear, but its exact amount was not determined because the conditions surrounding the several series were somewhat different, the recent improvements in method were not in use with

all of them. In all of the series up to the eighth there was more or less dilution of the cell contents, which certainly accounts for a part of the difference between the pressure observed then and that found in this series and others that have been carried out under the new conditions. If the temperature coefficient of osmotic pressure is to be measured, it is essential that the conditions surrounding the measurements in the several series be as near uniform as possible.

During the measurements taken at 20° during the early part of the year, the supply of sugar, which had been used for the series, became exhausted. A new supply of the purest rock candy obtainable was secured, but it showed evidence of the presence in it of considerable quantities of a reducing sugar. It was, therefore, found necessary to purify the sugar to be used. This purification has been carried on by Mr. W. M. Clark on a large scale. As much as 150 pounds of rock candy has been used. The method of purification is in brief as follows: The sugar is dissolved in a small amount of water at 60° and precipitated with 97% alcohol. At first this process was repeated three times. However, analyses of the material from the second and third crystallizations, as well as polariscope determinations and the measurement of the osmotic pressure, showed no difference in the two samples, so the last precipitation was omitted. The precipitate was washed with ethyl alcohol and finally with methyl alcohol. After being air dried at ordinary temperatures, the sugar was placed in a 60° air bath for several days, and finally dried over calcium chloride in a dessicator.

It is intended that enough sugar be prepared in this way to suffice for all future measurements with cane sugar. All the measurements at 5° were taken with sugar purified as above explained.

The tables which follow record the results of the work at 5° under the new conditions. These results will be compared with the results obtained in the series at other temperatures. The series at 0° and 10° have already been completed. Those at 15°, 20°, 25° and 30° will be carried out as soon as possible. Tables I-XXIII show the results of the individual measurements in some detail. Table XXIV gives the summarized results for each experiment, and in Table XXV the mean values for each concentration are shown. Tables XXVI and XXVII are introduced for the purpose of comparing the results obtained at 5° with those obtained at 0° and 10° in respect to the osmotic pressures and the ratio of osmotic to gas pressure.

TABLE I.

0.1 Wt. normal solution. Exp. No. 1. **Rotation:** (1) original, 12°.65; (2) at conclusion of expr., 12°.65; loss, 0.0. **Manometer:** No. 13; volume of nitrogen, 263.04; displacement, 0.0 M.M. Cell used, K_3. Resistance of membrane, 366,000. **Corrections:** (1) atmospheric pressure, 0.991; (2) liquids in manometer, 0.489; (3) dilution, 0; (4) concentration, 0; (5) capillary depression, 0.02. Initial pressure, 2.30. Time of setting up cell, 3:00 p. m., Feb. 22, 1909.

Time	Temperature Solution	Temperature Manometer	Volume N_2	Pressure Osmotic	Pressure Gas	Pressure Difference
Feb. 23.						
12:30 p. m.	5°.0	5°.0	89.21	2.455	2.267	0.188
4:30 p. m.	5°.0	5°.0	89.34	2.455	2.267	0.188
Feb. 24.						
9:00 a. m.	5°.0	5°.0	89.95	2.450	2.267	0.183
1:00 p. m.	5°.0	5°.0	90.12	2.447	2.267	0.180
				2.452	2.267	0.185

Molecular osmotic pressure, 24.520.
Molecular gas pressure, 22.674.
Ratio of osmotic to gas pressure, 1.082.

TABLE II.

0.1 Wt. normal solution. Exp. No. 2. **Rotation:** (1) original, 12°.65; (2) at conclusion of expr., 12°.65; loss, 0.0. **Manometer:** No. 6; volume of nitrogen, 412.00; displacement, 0.0 M.M. Cell used, L_3. Resistance of membrane, 550,000. **Corrections:** (1) atmospheric pressure, 0.999; (2) liquids in manometer, 0.419; (3) dilution, 0; (4) concentration, 0; (5) capillary depression, 0.02. Initial pressure, 2.39. Time of setting up cell, 3:00 p. m., Feb. 22, 1909.

Time	Temperature Solution	Temperature Manometer	Volume N_2	Pressure Osmotic	Pressure Gas	Difference
Feb. 23.						
9:00 a. m.	5°.0	5°.0	136.66	2.457	2.267	0.190
5:30 p. m.	5°.0	5°.0	136.59	2.453	2.267	0.186
Feb. 24.						
10:00 a. m.	5°.0	5°.0	136.77	2.447	2.267	0.180
2:00 p. m.	5°.0	5°.0	136.90	2.450	2.267	0.183
				2.452	2.267	0.185

Molecular osmotic pressure, 24.520.
Molecular gas pressure, 22.674.
Ratio of osmotic to gas pressure, 1.082.

TABLE III.

0.1 Wt. normal solution. Exp. No. 3. **Rotation:** (1) original, 12°.6; (2) at conclusion of expr., 12°.6; loss, 0.0. **Manometer:** No. 13; volume of nitrogen, 263.04; displacement, 0.0 M.M. Cell used, J_3. Resistance of membrane, 228,000. **Corrections:** (1) atmospheric pressure, 0.995; (2) liquids in manometer, 0.488; (3) dilution, 0; (4) concentration, 0; (5) capillary depression, 0.02. Initial pressure, 2.36. Time of setting up cell, 3:00 p. m., Feb. 25, 1909.

Time	Temperature Solution	Temperature Manometer	Volume N_2	Pressure Osmotic	Pressure Gas	Difference
Feb. 26.						
10:00 a. m.	5°.0	5°.0	89.27	2.453	2.267	0.186
4:30 p. m.	5°.0	5°.0	89.44	2.454	2.267	0.187
Feb. 27.						
1:00 a. m.	5°.0	5°.0	89.60	2.456	2.267	0.189
9:00 a. m.	5°.0	5°.0	89.65	2.448	2.267	0.181
				2.453	2.267	0.186

Molecular osmotic pressure, 24.530.
Molecular gas pressure, 22.674.
Ratio of osmotic to gas pressure, 1.082.

TABLE IV.

0.2 Wt. normal solution. Exp. No. 1. **Rotation:** (1) original, 24°.9; (2) at conclusion of expr., 24°.9; loss, 0.0. **Manometer:** No. 6; volume of nitrogen, 412.00; displacement, 0.0 M.M. Cell used, F_3. Resistance of membrane, 565,000. **Corrections:** (1) atmospheric pressure, 0.989; (2) liquids in manometer, 0.515; (3) dilution, 0; (4) concentration, 0; (5) capillary depression, 0.02. Initial pressure, 4.55. Time of setting up cell, 3:00 p. m., Jan. 25, 1909.

Time	Temperature Solution	Temperature Manometer	Volume N_2	Pressure Osmotic	Pressure Gas	Difference
Jan. 27.						
9:00 a. m.	5°.0	5°.0	77.90	4.813	4.535	0.278
11:00 p. m.	5°.0	5°.0	77.98	4.816	4.535	0.281
Jan. 28.						
9:00 a. m.	5°.0	5°.0	77.90	4.812	4.535	0.277
3:30 p. m.	5°.0	5°.0	77.97	4.807	4.535	0.272
				4.812	4.535	0.277

Molecular osmotic pressure, 24.060.
Molecular gas pressure, 22.674.
Ratio of osmotic to gas pressure, 1.061.

TABLE V.

0.2 Wt. normal solution. Exp. No. 2. **Rotation:** (1) original, 24°.95; (2) at conclusion of expr., 24°.95; loss, 0.0. **Manometer:** No. 9; volume of nitrogen, 454.14; displacement, 0.0 M.M. Cell used, J_3. Resistance of membrance, 270,000. **Corrections:** (1) atmospheric pressure, 0.996; (2) liquids in manometer, 0.507; (3) dilution, 0; (4) concentration, 0; (5) capillary depression, 0.02. Initial pressure, 4.70. Time of setting up cell, 12:00 m., Feb. 17, 1909.

Time	Temperature Solution	Temperature Manometer	Volume N_2	Pressure Osmotic	Pressure Gas	Pressure Difference
Feb. 18.						
9:00 a. m.	5°.0	5°.0	85.52	4.830	4.535	0.295
12:30 p. m.	5°.0	5°.0	85.51	4.833	4.535	0.298
Feb. 19.						
12:30 p. m.	5°.0	5°.0	85.98	4.820	4.535	0.285
4:00 p. m.	5°.0	5°.0	86.03	4.823	4.535	0.288
				4.826	4.535	0.291

Molecular osmotic pressure, 24.130.
Molecular gas pressure, 22.674.
Ratio of osmotic to gas pressure, 1.064.

TABLE VI.

0.3 Wt. normal solution. Exp. No. 1. **Rotation:** (1) original, 36°.6; (2) at conclusion of expr., 36°.6; loss, 0. **Manometer:** No. 6; volume of nitrogen, 412.00; displacement, 0.0 M.M. Cell used, J_3. Resistance of membrane, 366,500. **Corrections:** (1) atmospheric pressure, 0.997; (2) liquids in manometer, 0.527; (3) dilution, 0; (4) concentration, 0; (5) capillary depression, 0.02. Initial pressure, 5.66. Time of setting up cell, 3:30 p. m., Jan. 28, 1909.

Time	Temperature Solution	Temperature Manometer	Volume N_2	Pressure Osmotic	Pressure Gas	Pressure Difference
Jan. 29.						
9:00 a. m.	5°.0	5°.0	53.88	7.208	6.802	0.406
5:00 p. m.	5°.0	5°.0	54.10	7.190	6.802	0.388
Jan. 30.						
10:00 a. m.	5°.0	5°.0	54.11	7.187	6.802	0.385
1:00 p. m.	5°.0	5°.0	54.12	7.185	6.802	0.383
				7.193	6.802	0.391

Molecular osmotic pressure, 23.977.
Molecular gas pressure, 22.674.
Ratio of osmotic to gas pressure, 1.058.

TABLE VII.

0.3 Wt. normal solution. Exp. No. 2. **Rotation:** (1) original, 36°.6; (2) at conclusion of expr., 36°.6; loss, 0.0. **Manometer:** No. 9; volume of nitrogen, 454.14; displacement, 0.0 M.M. Cell used, K_3. Resistance of membrane, 224,000. **Corrections:** (1) atmospheric pressure, 0.994; (2) liquids in manometer, 0.544; (3) dilution, 0; (4) concentration, 0; (5) capillary depression, 0.02. Initial pressure, 6.89. Time of setting up cell, 12:30 p. m., Feb. 13, 1909.

Time	Temperature Solution	Temperature Manometer	Volume N_2	Pressure Osmotic	Pressure Gas	Pressure Difference
Feb. 15.						
12:00 m.	5.°0	5°.0	59.34	7.219	6.802	0.417
5:00 p. m.	5°.0	5°.0	59.41	7.212	6.802	0.410
11:00 p. m.	5°.0	5°.0	59.45	7.209	6.802	0.407
Feb. 16.						
12:00 m.	5°.0	5°.0	59.54	7.195	6.802	0.393
				7.209	6.802	0.407

Molecular osmotic pressure, 24.030.
Molecular gas pressure, 22.674.
Ratio of osmotic to gas pressure, 1.060.

TABLE VIII.

0.4 Wt. normal solution. Exp. No. 1. **Rotation:** (1) original, 47°.95; (2) at conclusion of expr., 47°.95; loss, 0.0. **Manometer:** No. 13; volume of nitrogen, 263 04; displacement, 0.0 M.M. Cell used, F_3. Resistance of membrane, 550,000. **Corrections:** (1) atmospheric pressure, 1.025; (2) liquids in manometer, 0.572; (3) dilution, 0; (4) concentration, 0; (5) capillary depression, 0.02. Initial pressure, 7.27. Time of setting up cell, 12:00 m., Jan. 30, 1909.

Time	Temperature Solution	Temperature Manometer	Volume N_2	Pressure Osmotic	Pressure Gas	Pressure Difference
Feb. 1.						
9:30 a. m.	5°.0	4°.95	26.20	9.622	9.070	0.552
1:00 p. m.	5°.0	5°.0	26.19	9.622	9.070	0.552
10:00 p. m.	5°.0	5°.0	26.18	9.623	9.070	0.553
Feb. 2.						
9:00 a. m.	5°.0	5°.0	26.19	9.625	9.070	0.555
				9.623	9.070	0.553

Molecular osmotic pressure, 24.058.
Molecular gas pressure, 22.674.
Ratio of osmotic to gas pressure, 1.061.

TABLE IX.

0.4 Wt. normal solution. Exp. No. 2. **Rotation:** (1) original, 47°.95; (2) at conclusion of expr., 47°.95; loss, 0.0. **Manometer:** No. 9; volume of nitrogen, 454.14; displacement, 0.0 M.M. Cell used, K_3. Resistance of membrane, 550,000. **Corrections:** (1) atmospheric pressure, 0.996; (2) liquids in manometer, 0.561; (3) dilution, 0; (4) concentration, 0; (5) capillary depression, 0.02. Initial pressure, 9.28. Time of setting up cell, 12:00 m., Jan. 30, 1909.

Time	Temperature Solution	Temperature Manometer	Volume N_2	Pressure Osmotic	Pressure Gas	Pressure Difference
Jan. 30.						
10:30 p. m.	5°.0	5°.0	45.21	9.644	9.070	0.574
Jan. 31.						
11:30 a. m.	5°.0	4°.95	45.21	9.631	9.070	0.561
5:30 p. m.	5°.0	4°.95	45.25	9.623	9.070	0.553
Feb. 1.						
4:00 p. m.	5°.0	5°.0	45.38	9.571	9.070	0.501
				9.617	9.070	0.547

Molecular osmotic pressure, 24.043.
Molecular gas pressure, 22.674.
Ratio of osmotic to gas pressure, 1.060.

TABLE X.

0.5 Wt. normal solution. Exp. No. 1. **Rotation:** (1) original, 58°.7; (2) at conclusion of expr., 58°.7; loss, 0.0. **Manometer:** No. 9; volume of nitrogen, 454.14; displacement, 0.0 M.M. Cell used, H_3. Resistance of membrane, 500,000. **Corrections:** (1) atmospheric pressure, 1.005; (2) liquids in manometer, 0.573; (3) dilution, 0; (4) concentration, 0; (5) capillary depression, 0.02. Initial pressure, 13.00. Time of setting up cell, 3:00 p. m., Jan. 21, 1909.

Time	Temperature Solution	Temperature Manometer	Volume N_2	Pressure Osmotic	Pressure Gas	Pressure Difference
Jan. 22.						
9:00 a. m.	5°.0	5°.0	36.22	12.122	11.337	0.785
1:00 p. m.	5°.0	5°.0	36.26	12.109	11.337	0.772
5:00 p. m.	5°.0	5°.1	36.30	12.097	11.337	0.760
Jan. 23.						
2:30 p. m.	5°.0	5°.0	36.52	12.028	11.337	0.691
				12.089	11.337	0.752

Molecular osmotic pressure, 24.176.
Molecular gas pressure, 22.674.
Ratio of osmotic to gas pressure, 1.066.

TABLE XI.

0.5 Wt. normal solution. Exp. No. 2. **Rotation:** (1) original 58°.7; (2) at conclusion of expr., 58°.7; loss, 0.0. **Manometer:** No. 13; volume of nitrogen, 263.04; displacement, 0.0 M.M. Cell used, E_8. Resistance of membrane, 550,000. **Corrections:** (1) atmospheric pressure, 0.999; (2) liquids in manometer, 0.580; (3) dilution, 0; (4) concentration, 0; (5) capillary depression, 0.02. Initial pressure, 10.74. Time of setting up cell, 3:30 p. m., Jan. 22, 1909.

Time	Temperature Solution	Temperature Manometer	Volume N_2	Pressure Osmotic	Pressure Gas	Pressure Difference
Jan. 23.						
3:00 a. m.	5°.0	5°.2	21.04	12.088	11.337	0.751
2:30 p. m.	5°.0	5°.0	21.04	12.100	11.337	0.763
Jan. 24.						
5:00 p. m.	5°.0	5°.2	21.06	12.097	11.337	0.760
Jan. 25.						
9:00 a. m.	5°.0	5°.05	21.07	12.087	11.337	0.750
				12.093	11.337	0.756

Molecular osmotic pressure, 24.186.
Molecular gas pressure, 22.674.
Ratio of osmotic to gas pressure, 1.067.

TABLE XII.

0.6 Wt. normal solution. Exp. No. 1. **Rotation:** (1) original, 69°.2; (2) at conclusion of expr., 69°.2; loss, 0.0. **Manometer:** No. 20; volume of nitrogen, 411.07; displacement, 0.0 M.M. Cell used, L_3. Resistance of membrane, 370,000. **Corrections:** (1) atmospheric pressure, 1.001; (3) liquids in manometer, 0.578; (3) dilution, 0; (4) concentration, 0; (5) capillary depression, 0.02. Initial pressure, 13.59. Time of setting up cell, 4:00 p. m., Feb. 1, 1909.

Time	Temperature Solution	Temperature Manometer	Volume N_2	Pressure Osmotic	Pressure Gas	Pressure Difference
Feb. 2.						
9:00 a. m.	5°.0	5°.0	27.38	14.611	13.604	1.007
4:30 p. m.	5°.0	5°.0	27.40	14.601	13.604	0.997
Feb. 3.						
9:00 a. m.	5°.0	5°.0	27.41	14.599	13.604	0.995
12:30 p. m.	5°.0	5°.0	27.40	14.608	13.604	1.004
				14.605	13.604	1.001

Molecular osmotic pressure, 24.342.
Molecular gas pressure, 22.674.
Ratio of osmotic to gas pressure, 1.074.

TABLE XIII.

0.6 Wt. normal solution. Exp. No. 2. **Rotation:** (1) original, 69°.2; (2) at conclusion of expr., 69°.2; loss, 0.0. **Manometer:** No. 11; volume of nitrogen, 431.37; displacement, 0.0 M.M. Cell used, I_3. Resistance of membrane, 367,000. **Corrections:** (1) atmospheric pressure, 1.001; (2) liquids in manometer, 0.561; (3) dilution, 0; (4) concentration, 0; (5) capillary depression, 0.02. Initial pressure, 10.28. Time of setting up cell, 4:00 p. m., Feb. 1, 1909.

Time	Temperature Solution	Temperature Manometer	Volume N_2	Pressure Osmotic	Pressure Gas	Pressure Difference
Feb. 2.						
9:00 a. m.	5°.0	5°.0	28.69	14.604	13.604	1.000
1:00 p. m.	5°.0	5°.0	28.68	14.617	13.604	1.013
Feb. 3.						
9:00 a. m.	5°.0	5°.0	28.72	14.602	13.604	0.998
12:30 p. m.	5°.0	5°.0	28.75	14.591	13.604	0.987
				14.604	13.604	1.000

Molecular osmotic pressure, 24.340.
Molecular gas pressure, 22.674.
Ratio of osmotic to gas pressure, 1.074.

TABLE XIV.

0.7 Wt. normal solution. Exp. No. 1. **Rotation:** (1) original, 79°.3; (2) at conclusion of expr., 79°.3; loss, 0.0. **Manometer:** No. 9; volume of nitrogen, 454.14; displacement, 0.0 M.M. Cell used, M_3. Resistance of membrane, 275,000. **Corrections:** (1) atmospheric pressure, 0.994; (2) liquids in manometer, 0.585; (3) dilution, 0; (4) concentration, 0; (5) capillary depression, 0.02. Initial pressure, 15.51. Time of setting up cell, 3:30 p. m., Feb. 2, 1909.

Time	Temperature Solution	Temperature Manometer	Volume N_2	Pressure Osmotic	Pressure Gas	Pressure Difference
Feb. 3.						
12:30 p. m.	5°.0	5°.0	25.77	17.235	15.872	1.363
10:00 p. m.	5°.0	5°.0	25.79	17.220	15.872	1.348
Feb. 4.						
9:30 a. m.	5°.0	5°.05	25.80	17.215	15.872	1.343
3:00 p. m.	5°.0	5°.0	25.83	17.199	15.872	1.327
				17.217	15.872	1.345

Molecular osmotic pressure, 24.596.
Molecular gas pressure, 22.674.
Ratio of osmotic to gas pressure, 1.085.

TABLE XV.

0.7 Wt. normal solution. Exp. No. 2. **Rotation:** (1) original, 79°.2; (2) at conclusion of expr., 79°.2; loss, 0.0. **Manometer:** No. 6; volume of nitrogen, 412.00; displacement, 0.0 M.M. Cell used, J_3. Resistance of membrane, 270.000. **Corrections:** (1) atmospheric pressure, 1.004; (2) liquids in manometer, 0.569; (3) dilution, 0; (4) concentration, 0; (5) capillary depression, 0.02. Initial pressure, 15.11. Time of setting up cell, 12:30 p. m., Feb. 11, 1909.

Time	Temperature Solution	Temperature Manometer	Volume N_2	Pressure Osmotic	Pressure Gas	Pressure Difference
Feb. 12.						
1:00 p. m.	5°.0	5°.0	23.39	17.196	15.872	1.324
5:00 p. m.	5°.0	5°.0	23.41	17.185	15.872	1.313
Feb. 13.						
10:30 a. m.	5°.0	5°.1	23.40	17.192	15.872	1.320
3:00 p. m.	5°.0	5°.0	23.39	17.204	15.872	1.332
				17.194	15.872	1.322

Molecular osmotic pressure, 24.563.
Molecular gas pressure, 22.674.
Ratio of osmotic to gas pressure, 1.083.

TABLE XVI.

0.8 Wt. normal solution. Exp. No. 1. **Rotation:** (1) original, 89°.0; (2) at conclusion of expr., 89°.0; loss, 0.0. **Manometer:** No. 20; volume of nitrogent, 411.07; displacement, 0.0 M.M. Cell used, J_3. Resistance of membrane, 275,000. **Corrections:** (1) atmospheric pressure, 0.986; (2) liquids in manometer, 0.586; (3) dilution, 0; (4) concentration, 0; (5) capillary depression, 0.02. Initial pressure, 19.50. Time of setting up cell, 12:30 p. m., Feb. 4, 1909.

Time	Temperature Solution	Temperature Manometer	Volume N_2	Pressure Osmotic	Pressure Gas	Pressure Difference
Feb. 4.						
10:00 p. m.	5°.0	4°.95	20.37	19.797	18.139	1.658
Feb. 5.						
1:00 p. m.	5°.0	5°.0	20.38	19.788	18.139	1.649
9:30 p. m.	5°.0	5°.4	20.33	19.802	18.139	1.663
Feb. 6.						
12:00 m.	5°.0	5°.0	20.38	19.793	18.139	1.654
				19.795	18.139	1.656

Molecular osmotic pressure ,24.744.
Molecular gas pressure, 22.674.
Ratio of osmotic to gas pressure, 1.091.

TABLE XVII.

0.8 Wt. normal solution. Exp. No. 2. **Rotation:** (1) original, 89°.0; (2) at conclusion of expr., 89°.0; loss, 0.0. **Manometer:** No. 9; volume of nitrogen, 454.14; displacement, 0.0 M.M. Cell used, B_3. Resistance of membrane, 550,000. **Corrections:** (1) atmospheric pressure, 0.985; (2) liquids in manometer, 0.591; (3) dilution, 0; (4) concentration, 0; (5) capillary depression, 0.02. Initial pressure, 16.61. Time of setting up cell, 3:00 p. m., Feb. 9, 1909.

Time	Temperature Solution	Temperature Manometer	Volume N_2	Pressure Osmotic	Pressure Gas	Difference
Feb. 10.						
9:00 a. m.	5°.0	5°.05	22.49	19.826	18.139	1.687
5:00 p. m.	5°.0	5°.0	22.46	19.850	18.139	1.711
10:30 p. m.	5°.0	5°.0	22.45	19.853	18.139	1.714
Feb. 11.						
2:30 p. m.	5°.0	5°.05	22.44	19.853	18.139	1.714
				19.845	18.139	1.706

Molecular osmotic pressure, 24.806.
Molecular gas pressure, 22.674.
Ratio of osmotic to gas pressure, 1.094.

TABLE XVIII.

0.9 Wt. normal solution. Exp. No. 1. **Rotation:** (1) original, 98°.35; (2) at conclusion of expr., 98°.35; loss, 0.0. **Manometer:** No. 20; volume of nitrogen, 411.13; displacement, 0.0 M.M. Cell used, O_3. Resistance of membrane, 550,000. **Corrections:** (1) atmospheric pressure, 1.005; (2) liquids in manometer, 0.590; (3) dilution, 0; (4) concentration, 0; (5) capillary depression, 0.02. Initial pressure, 22.06. Time of setting up cell, 3:00 p. m., Feb. 19, 1909.

Time	Temperature Solution	Temperature Manometer	Volume N_2	Pressure Osmotic	Pressure Gas	Difference
Feb. 22.						
9:00 a. m.	5°.0	5°.0	18.00	22.448	20.406	2.042
2:30 p. m.	5°.0	5°.0	18.00	22.447	20.406	2.041
10:00 p. m.	5°.0	5°.0	18.00	22.445	20.406	2.039
Feb. 23.						
9:00 a. m.	5°.0	5°.0	18.01	22.433	20.406	2.027
				22.443	20.406	2.037

Molecular osmotic pressure, 24.937.
Molecular gas pressure, 22.674.
Ratio of osmotic to gas pressure, 1.100.

TABLE XIX.

0.9 Wt. normal solution. Exp. No. 2. **Rotation:** (1) original, 98°.25; (2) at conclusion of expr., 98°.25; loss, 0.0. **Manometer:** No. 9; volume of nitrogen, 454.14; displacement, 0.0 M.M. Cell used, B_3. Resistance of membrane, 500,000. **Corrections:** (1) atmospheric pressure, 1.008; (2) liquids in manometer, 0.584; (3) dilution, 0; (4) concentration, 0; (5) capillary depression, 0.02. Initial pressure, 17.11. Time of setting up cell, 3.00 p. m., Jan. 18, 1909.

Time	Temperature Solution	Temperature Manometer	Volume N_2	Pressure Osmotic	Pressure Gas	Difference
Jan. 19.						
5:00 p. m.	5°.0	5°.0	19.93	22.391	20.406	1.985
Jan. 20.						
10:00 a. m.	5°.0	5°.0	19.87	22.463	20.406	2.057
Jan. 21.						
1:00 a. m.	5°.0	4°.8	19.80	22.542	20.406	2.136
9:00 a. m.	5°.0	5°.0	19.80	22.545	20.406	2.139
				22.485	20.406	2.079

Molecular osmotic pressure, 24.983.
Molecular gas pressure, 22.674.
Ratio of osmotic to gas pressure, 1.102.

TABLE XX.

1.0 Wt. normal solution. Exp. No. 1. **Rotation:** (1) original, 107°.3; (2) at conclusion of expr., 107°.3; loss, 0.0. **Manometer:** No. 20; volume of nitrogen, 411.07; displacement, 0.0 M.M. Cell used, C_3. Resistance of membrane, 550,000. **Corrections:** (1) atmospheric pressure, 1.009; (2) liquids in manometer, 0.592; (3) dilution, 0; (4) concentration, 0 ;(5) capillary depression, 0.02. Initial pressure, 20.12. Time of setting up cell, 12:30 p. m., Jan. 16, 1909.

Time	Temperature Solution	Temperature Manometer	Volume N_2	Pressure Osmotic	Pressure Gas	Pressure Difference
Jan. 18.						
5:00 a. m.	5°.0	4°.95	16.00	25.305	22.674	2.631
1:00 p. m.	5°.0	5°.0	16.02	25.269	22.674	2.595
9:30 p. m.	5°.0	5°.0	16.01	25.279	22.674	2.605
Jan. 19.						
1:00 p. m.	5°.0	5°.0	16.00	25.301	22.674	2.627
				25.289	22.674	2.615

Molecular osmotic pressure, 25.289.
Molecular gas pressure, 22.674.
Ratio of osmotic to gas pressure, 1.115.

TABLE XXI.

1.0 Wt. normal solution. Exp. No. 2. **Rotation:** (1) original, 107°.3; (2) at conclusion of expr., 107°.3; loss, 0.0. **Manometer:** No. 9; volume of nitrogen, 454.14; displacement, 0.0 M.M. Cell used, K_3. Resistance of membrane, 1,100,000. **Corrections:** (1) atmospheric pressure, 1.001; (2) liquids in manometer, 0.597; (3) dilution, 0; (4) concentration, 0; (5) capillary depression, 0.02. Initial pressure, 21.83. Time of setting up cell, 12:30 p. m., Jan. 16, 1909.

Time	Temperature Solution	Temperature Manometer	Volume N_2	Pressure Osmotic	Pressure Gas	Pressure Difference
Jan. 16.						
9:00 a. m.	5°.0	5°.0	17.67	25.316	22.674	2.642
Jan. 17.						
7:30 a. m.	5°.10	4°.95	17.68	25.309	22.674	2.635
11:00 a. m.	5°.05	4°.95	17.68	25.309	22.674	2.635
9:00 p. m.	5°.0	5°.0	17.71	25.252	22.674	2.578
				25.297	22.674	2.623

Molecular osmotic pressure, 25.297.
Molecular gas pressure, 22.674.
Ratio of osmotic to gas pressure, 1.115.

TABLE XXII.

1.0 Wt. normal solution. Exp. No. 3. **Rotation:** (1) original, 107°.3; (2) at conclusion of expr., 107°.3; loss, 0.0. **Manometer:** No. 21; volume of nitrogen, 400.14; displacement, 0.0 M.M. Cell used, F_3. Resistance of membrane, 1,000,000. **Corrections:** (1) atmospheric pressure, 1.005; (2) liquids in manometer, 0.642; (3) dilution, 0; (4) concentration, 0; (5) capillary depression, 0.02. Initial pressure, 18.56. Time of setting up cell, 4:30 p. m., Jan. 13, 1909.

Time	Temperature Solution	Temperature Manometer	Volume N_2	Pressure Osmotic	Pressure Gas	Pressure Difference
Jan. 14.						
1:00 p. m.	5°.0	5°.0	15.59	25.315	22.674	2.641
5:00 p. m.	5°.0	5°.1	15.59	25.325	22.674	2.651
Jan. 15.						
12:30 a. m.	4°.95	5°.05	15.58	25.322	22.674	2.648
12:30 p. m.	5°.0	5°.0	15.61	25.286	22.674	2.612
				25.312	22.674	2.638

Molecular osmotic pressure, 25.312.
Molecular gas pressure, 22.674.
Ratio of osmotic to gas pressure, 1.116.

TABLE XXIII.

1.0 Wt. normal solution. Exp. No. 4. **Rotation:** (1) original, 107°.3; (2) at conclusion of expr., 107°.3; loss, 0.0. **Manometer:** No. 21; volume of nitrogen, 400.14; displacement, 0.0 M.M. Cell used, J_3. Resistance of membrane, 1,100,000. **Corrections:** (1) atmospheric pressure, 1.004; (2) liquids in manometer, 0.642; (3) dilution, 0; (4) concentration, 0; (5) capillary depression, 0.02. Initial pressure, 20.15. Time of setting up cell, 12:30 p. m., Jan. 16, 1909.

Time	Temperature Solution	Temperature Manometer	Volume N_2	Pressure Osmotic	Pressure Gas	Pressure Difference
Jan. 16.						
9:00 a. m.	5°.0	5°.0	15.64	25.234	22.674	2.560
Jan. 17.						
11:00 a. m.	5°.05	4°.95	15.61	25.304	22.674	2.630
9:00 a. m.	5°.0	5°.0	15.63	25.257	22.674	2.583
Jan. 18.						
9:30 a. m.	5°.0	5°.0	15.64	25.232	22.674	2.558
				25.257	22.674	2.583

Molecular osmotic pressure, 25.257.
Molecular gas pressure, 22.674.
Ratio of osmotic to gas pressure, 1.114.

TABLE XXIV—SUMMARY OF RESULTS AT 5°.

Weight normal concentration	Osmotic pressure	Gas pressure	Difference	Molecular osmotic pressure	Molecular gas pressure	Ratio of osmotic to gas pressure
0.1	2.452	2.267	0.185	24.520	22.674	1.082
0.1	2.452	2.267	0.185	24.520	22.674	1.082
0.1	2.453	2.267	0.186	24.530	22.674	1.082
0.2	4.812	4.535	0.277	24.060	22.674	1.061
0.2	4.826	4.535	0.291	24.130	22.674	1.064
0.3	7.193	6.802	0.391	23.977	22.674	1.058
0.3	7.209	6.802	0.407	24.030	22.674	1.060
0.4	9.623	9.070	0.553	24.058	22.674	1.061
0.4	9.617	9.070	0.547	24.043	22.674	1.060
0.5	12.089	11.337	0.752	24.176	22.674	1.066
0.5	12.093	11.337	0.756	24.186	22.674	1.067
0.6	14.605	13.604	1.001	24.342	22.674	1.074
0.6	14.604	13.604	1.000	24.340	22.674	1.074
0.7	17.217	15.872	1.345	24.596	22.674	1.085
0.7	17.194	15.872	1.322	24.563	22.674	1.083
0.8	19.795	18.139	1.656	24.744	22.674	1.091
0.8	19.845	18.139	1.706	24.806	22.674	1.094
0.9	22.443	20.406	2.037	24.937	22.674	1.100
0.9	22.485	20.406	2.079	24.983	22.674	1.102
1.0	25.289	22.674	2.615	25.289	22.674	1.115
1.0	25.297	22.674	2.623	25.297	22.674	1.115
1.0	25.312	22.674	2.638	25.312	22.674	1.116
1.0	25.257	22.674	2.583	25.257	22.674	1.114

TABLE XXV—SUMMARY OF RESULTS AT 5° MEAN VALUES.

Weight normal concentration	Osmotic pressure	Gas pressure	Difference	Molecular osmotic pressure	Molecular gas pressure	Ratio of osmotic to gas pressure
0.1	2.452	2.267	0.185	24.523	22.674	1.082
0.2	4.819	4.535	0.284	24.095	22.674	1.063
0.3	7.201	6.802	0.399	24.003	22.674	1.059
0.4	9.620	9.070	0.550	24.050	22.674	1.061
0.5	12.091	11.337	0.754	24.181	22.674	1.067
0.6	14.605	13.604	1.001	24.341	22.674	1.074
0.7	17.206	15.872	1.334	24.580	22.674	1.084
0.8	19.820	18.139	1.681	24.775	22.674	1.093
0.9	22.464	20.406	2.058	24.960	22.674	1.101
1.0	25.289	22.674	2.615	25.289	22.674	1.115

TABLE XXVI. OSMOTIC PRESSURES AT 0° 5°, and 10°.

Weight normal concentration	0°	5°	10°
0.1	.....	2.452	2.497
0.2	4.724	4.819	4.895
0.3	7.075	7.201	.....
0.4	9.450	9.620	9.790
0.5	11.897	12.091	12.297
0.6	14.380	14.605	14.851
0.7	16.892	17.206	17.501
0.8	19.476	19.820	20.161
0.9	22.118	22.464	22.886
1.0	24.832	25.289	25.697
1. Total pressure 0.4 to 1.0 N. concentration.....	119.045	121.095	123.183
2. Mean ratio of osmotic to gas pressure, 0.4 to 1.0 N. concentration.....	1.090	1.090	1.089

TABLE XXVII—MEAN RATIO OF OSMOTIC TO GAS PRESSURES AT 0°, 5°, AND 10°

Weight normal concentration	0°	5°	10°	Mean ratios
0.1	.....	1.082	1.082	1.082
0.2	1.061	1.063	1.061	1.062
0.3	1.059	1.059	.....	1.059
0.4	1.061	1.061	1.061	1.061
0.5	1.069	1.067	1.066	1.067
0.6	1.076	1.074	1.072	1.074
0.7	1.084	1.084	1.083	1.084
0.8	1.094	1.093	1.092	1.093
0.9	1.104	1.101	1.102	1.102
1.0	1.115	1.115	1.114	1.115

With reference to Tables I-XXIII it is only necessary to call attention to the fact that the series of measurements was carried out without the least trace of loss in rotation. The solution from the cell after each measurement gave the same rotation as a part of the original solution, which was saved for this purpose. Table XXIV shows the osmotic pressure, gas pressure, the difference between the two, the molecular osmotic and gas pressures, and the ratio of osmotic to gas pressure. A glance at the ratios obtained in duplicate experiments will show how good the agreement in the work has been, when it is understood that exceptional difficulties had to be overcome.

In the 0.1 and 0.6 normal concentrations the difference in the ratio is not apparent in the third decimal place. In no case is the difference in the ratio greater than three in the third decimal place. In two cases the difference in the ratio amounted to three in the third decimal place. In the one case the difference in actual osmotic pressure was only 0.05 of an atmosphere, in the other still less. The more concentrated the solution the less is the ratio influenced by a difference in the actual pressures measured. The largest divergence in actual pressures occurs with the normal concentration, as would be expected. Here the difference between the highest and lowest of four measurements is only 0.055 of an atmosphere. In other cases, the difference is much less and in some there is no difference at all.

Table XXV shows the mean values. Attention may be called to the somewhat regular way in which the ratios decrease from 1.0 to 0.4 normal concentration. A minimum is reached at 0.3 normal,

which, however, is very little lower than the ratios at 0.4 and 0.2 normal, which are very nearly equal. With the 0.1 normal there is a notable rise in the ratio.

Table XXVI gives the actual pressures measured at 0°, 5°, and 10°, with the exception of the 0.3 normal concentration in the case of the 10° series, and the 0.1 normal concentration in the 0° series. The measurement of the pressure of these concentrations has not been finished. Horizontal column numbered 1 in this table gives the total osmotic pressure measured for concentrations 0.4 normal to 1.0 normal inclusive. The three lower concentrations are omitted from this summation because of the blanks at 0.3 normal in the 10° series and at 0.1 normal in 0° series. It will be seen that the mean ratios of osmotic to gas pressure calculated from the total pressures of the three series are strikingly concordant. The meaning of this is obviously that the law of Gay-Lussac for gas pressure holds for the osmotic pressure of cane sugar solutions within the temperatures and concentrations in question, since the gas pressures used in calculating the ratios are determined from Gay-Lussac's law.

The average ratios for each of the three series are arranged in parallel columns in Table XXVII. The ratios for the different concentrations for each series may here be compared with the other two. The agreement in every case is excellent. A fourth column shows the mean ratios for the three series. In no case is the difference of any ratio from the mean greater than two in the third decimal place, and in most cases it is less. More than half of the individual ratios agree exactly with the mean. When the work at 15°, 20°, 25°, and 30° is completed the results then obtained must be compared with those here set forth.

As far as the work has proceeded it can certainly be concluded that there is a temperature coefficient for the osmotic pressure of cane sugar solutions between 0.1 and 1.0 weight normal concentrations, and that this temperature coefficient is substantially identical with that for gases.

BIOGRAPHY.

Eugene Edward Gill was born September 17, 1875, at Boring, Maryland. His early education was obtained in the Baltimore County public schools and at Franklin High School, Reisterstown, Maryland. He entered Dickinson College, Carlisle, Pennsylvania, in the fall of 1893, and received the degree of Ph. B. in 1897, and that of A. M. in 1898. During the year 1897-98 he was principal of the Montgomery (Pa.) High School. From 1898-1900 he taught Mathematics and Science in Morrisville College, Morrisville, Missouri. From 1900 to 1903 he engaged in business, and from 1903 to 1906 he was instructor of Chemistry and Physics in The Colorado State Preparatory School, Boulder, Colorado. In the fall of 1906, he entered The Johns Hopkins University as a graduate student in the chemical department. His subordinate subjects are Physical Chemistry and Mineralogy. While here he has served one year as laboratory assistant, and one year as lecture assistant to Professor Renouf.